Zootaxa 2796: 1–14 (2011)
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

The genus *Benthofascis* (Gastropoda: Conoidea): A revision with descriptions of new species

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Abstract

The conoidean gastropod genus *Benthofascis* Iredale, 1936 is examined. This genus of Conorbidae has extant species. Three previously described species from the Recent including the type species *B. biconica* (Hedley), *B. sarcinula* (Hedley), and *B. lozoueti* Sysoev & Bouchet are reviewed. Three new species from the Recent, *B. conorbioides* **sp. nov.**, *B. pseudobiconica* **sp. nov.**, and *B. angularis* **sp. nov.** are described from Australia. One of these (*B. angularis*) is the first *Benthofascis* species described from Western Australia. Two fossil species originally described as *Conorbis* from the Miocene and Oligocene of Australia (*C. atractoides* Tate and *C. otwayensis* Long, respectively) are for the first time assigned to *Benthofascis*, thus extending the geologic record of the genus to the Oligocene.

Key words: Conoidea, Conorbidae, *Benthofascis*, *Conorbis*, new species, new geologic records

Introduction

The conorbids (*sensu lato*) have had a complicated systematic history. Powell (1966) restricted Conorbinae (as a subfamily of Turridae) to four genera including *Conorbis* Swainson, 1840, *Cryptoconus* von Koenen, 1867, *Benthofascis* Iredale, 1936, and *Genota* H. & A. Adams, 1853. Tucker & Tenorio (2009) excluded *Cryptoconus* and *Genota* because they do not resorb their inner whorls and added *Artemidiconus* da Motta, 1991 to the family. Of the three genera included in Conorbidae by Tucker & Tenorio (2009) one is extinct (i.e., *Conorbis*), which we do not consider here. The other two genera are either represented primarily by Recent species (*Benthofascis*) or known only from the Recent (*Artemidiconus*). We review the species of *Benthofascis* here.

Genera of the family Conorbidae are united by two characteristics, namely the complete absence of nodules and remodelling of the shell interior (Tucker & Tenorio 2009). They possess several primitive radular character states that serve to put them between genera without remodelled interior shell walls and the remainder of the conoidean families. Genera with living representatives have radular teeth that are only slightly enrolled and that do not have the folds that are present in other families (Tucker & Tenorio 2009). One species, currently described in *Benthofascis*, *B. lozoueti* Sysoev & Bouchet, 2001 differs from all recent Conorbidae by not having resorbed inner whorls (Fig. 3H) and a nearly smooth protoconch (Figs. 3J & K) but does share the blunt protoconch and lack of nodules with other *Benthofascis* species. That lack of resorbed whorls does not automatically exclude *B. lozoueti* from *Benthofascis* or Conorbidae, because resorption of inner whorls is a derived state (Kohn 1990; Tucker & Tenorio 2009). However, the phylogenetic position of *B. lozoueti* is currently being clarified using molecular characters (Puillandre *et al*. pers. com.).

A number of other species have been placed as conorbids. Thiele (1929) placed *Conus coromandelicus* (E. A. Smith 1894) in *Conorbis* but Powell (1966) did not accept that assignment, suggesting that the radula illustrated by Thiele (1929, Fig. 460, see also Tucker & Tenorio 2009, Plate XV, Fig. 6) placed the species in Conidae (*sensu* Powell). Tucker & Tenorio (2009) erected the genus *Pseudoconorbis* for this species and placed it in their family

Accepted by M. deMaintenon: 7 Mar. 2011; published: 21 Mar. 2011

Conilithidae. Species of *Conorbis* and of *Pseudoconorbis* differ in shell morphology. Species included in *Conorbis* do not have nodules, whereas species included in *Pseudoconorbis* have nodulose early to middle spire whorls (Tucker & Tenorio 2009; Tucker & Stahlschmidt 2010). Bozzetti (1994) described *Conorbis adamii* as an extant species of *Conorbis*. However, Vera-Peláez (2004) placed Bozzetti's species in a new genus, *Genotina* Vera-Peláez, 2004. Species in this genus do not resorb the inner shell walls (Tucker & Tenorio 2009) and the genus does not belong in Conorbidae.

The genus *Benthofascis* also has a complicated taxonomic history especially at the family level. For instance, it has been included in the Turridae (subfamily Conorbinae Powell 1942) according to Powell (1966) and Millard (2003), in the Conidae according to Taylor *et al*. (1993) and Bouchet & Rocroi (2005), or in the Conorbidae according to Tucker & Tenorio (2009). The latter authors diagnosed the genus using shell and radular traits. They included three species: *Benthofascis biconica* (Hedley 1903), *B. sarcinula* (Hedley 1905) and *B. lozoueti* Sysoev & Bouchet, 2001. The genus had no fossil representatives (Tucker & Tenorio 2009).

Examination of type specimens for these three species suggests that *Benthofascis biconica* Auctorum is actually applied to two species one of which is not described. In addition two further new Recent species have been found. We also include two fossil species in *Benthofascis*, which had been included in *Conorbis* (Tate 1890; Long 1981; Tucker & Tenorio 2009). The two extinct species extend the fossil record of the genus into the Oligocene of Australia. Finally for the first time, we illustrate the radular teeth of three of these species using both photomicrographs and drawings. We confirm that all of the species of *Benthofascis* excepting *B. lozoueti* have resorbed inner whorls using x-ray images.

Material and methods

The material studied here was mostly previously deposited in institutional repositories. However, significant new material was gathered by the third author from various private sources and deposited in institutional repositories for the most part. Descriptions and measurements are based on shells oriented in the traditional way, spire up with the aperture facing the viewer. Shell terminology used herein follows Röckel *et al*., 1995. Radular terminology follows Tucker & Tenorio, 2009.

The specimens used in radular preparations had been preserved in 5% formalin and seawater at AMS. The soft parts were extracted from their corresponding shells and digested in concentrated aqueous KOH for 24 h. After that time, the resulting mixture was placed in a Petri dish and examined with the binocular microscope. In each case, the entire radula was separated from the remaining of the soft parts using fine tweezers and rinsed with distilled water. Then, the radula was mounted on a slide using Aquatex (Merck) Mounting Medium, and examined under the optical microscope. Photos were obtained with a CCD camera attached to the microscope, and were used for making the line drawings.

Abbreviations

AMS	Australian Museum, Sydney
ANSP	Academy of Natural Sciences, Philadelphia
MHNH	Muséum national d'Histoire naturelle, Paris
NMNZ	Museum of New Zealand Te Papa Tongarewa, Wellington
NMSA	Natal Museum, Pietermaritzburg
NMVM	National Museum Victoria, Victoria
SAMA	South Australia Museum, Adelaide
SBMNH	Santa Barbara Museum of Natural History, Santa Barbara
SMF	Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt
USNM	National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Taxonomy

Conorbidae Powell, 1942

Type genus: *Conorbis* Swainson, 1840

Diagnosis. The interior of the shell is extensively remodeled including the columellar region; nodules are absent at least on the first few teleoconch whorls; spirals are usually present on the sutural ramps of the teleoconch whorls, shell shape ranges from squatly conical to elongated or biconic. The radular tooth is simple with a barb and short blade; a basal spur is present; serrations and terminating cusps are absent (diagnosis adapted from Tucker & Tenorio 2009).

Genus: *Benthofascis* Iredale, 1936

Type species by original designation *Bathytoma biconica* Hedley, 1903

Diagnosis. Two or more spirals on the sutural ramps of the teleoconch; nodules absent; shells biconical with scalariform spire whorls; anal notch deep and not symmetrical; protoconch of 2.5 or fewer blunt and swollen whorls; protoconch smooth or ornamented by spirals and axials after a short smooth section; interior shell walls typically resorbed with the exception of *Benthofascis lozoueti,* which is somewhat doubtfully referred to *Benthofascis*. Radula is simple with a blade and barb and indistinct waist. The radular tooth has a c-fold and a waist fold; the barb and blade are small; the homologue of the basal spur is directed perpendicular to the tooth shaft rather than towards the apex of the tooth; a shaft fold is absent (after Tucker & Tenorio 2009).

Key to the Recent species of *Benthofascis*

1.	First two whorls of the protoconch appear smooth because spiral ridges are extremely minute and numerous	*Benthofacies lozoueti* Sysoev & Bouchet, 2001
-	Spirals and axials on the first two whorls of the protoconch are not minute but are quite obvious	2
2.	First ornamented teleoconch whorl has numerous (more than 5) minute spirals crossed by axials	*B. sarcinula* (Hedley, 1905)
-	First ornamented teleoconch whorl has 4–5 spirals	3
3.	Shoulder is angular	4
-	Shoulder is not angular	5
4.	Body whorl is covered with spirals	*B. biconica* (Hedley, 1903)
-	Posterior part of the body whorl is smooth	*B. angularis* new species
5.	Teleoconch with strong wide spirals separated by narrow interspaces	*B. conorbioides* new species
-	Teleoconch with weak spirals separated by wide interspaces	*B. pseudobiconica* new species

Benthofascis biconica (Hedley, 1903)

Figures 1, A–F; 4, A–D

Type material. Holotype is AMS C.016448, shell length 18 mm, shell width 8 mm.

Type locality. 35–37 m, Shoalhaven Bight, New South Wales, Australia

Other specimens. AMS C.468235, 4 specimens from 71–77 m deep, 5.7 km E of Mistral Point, Sydney, New South Wales, 33º56.470'S, 151º19.630'E, dredged, 20 July 1972, Station: SBS 2; AMS C.468237, 2 specimens from 9 m, Twofold Bay, New South Wales, 37º5'S, 149º55'E; AMS C.388783, 2 specimens from 66 m, off North Head, Sydney, New South Wales, 33º49.5'S, 151º18.1'E; AMS C.468232, 1 specimen from 71–77 m, 5.7 km E of Mistral Point, Sydney, New South Wales, 33º56.470'S, 151º19.630'E (wet); AMS C.468233, 1 specimen from 77 m, 5 km E of Long Bay, Sydney, New South Wales, 33º58.150'S, 151º18.020'E, dredged 20 February, 1973, Shelf Benthic Survey.

Range. New South Wales, Australia.

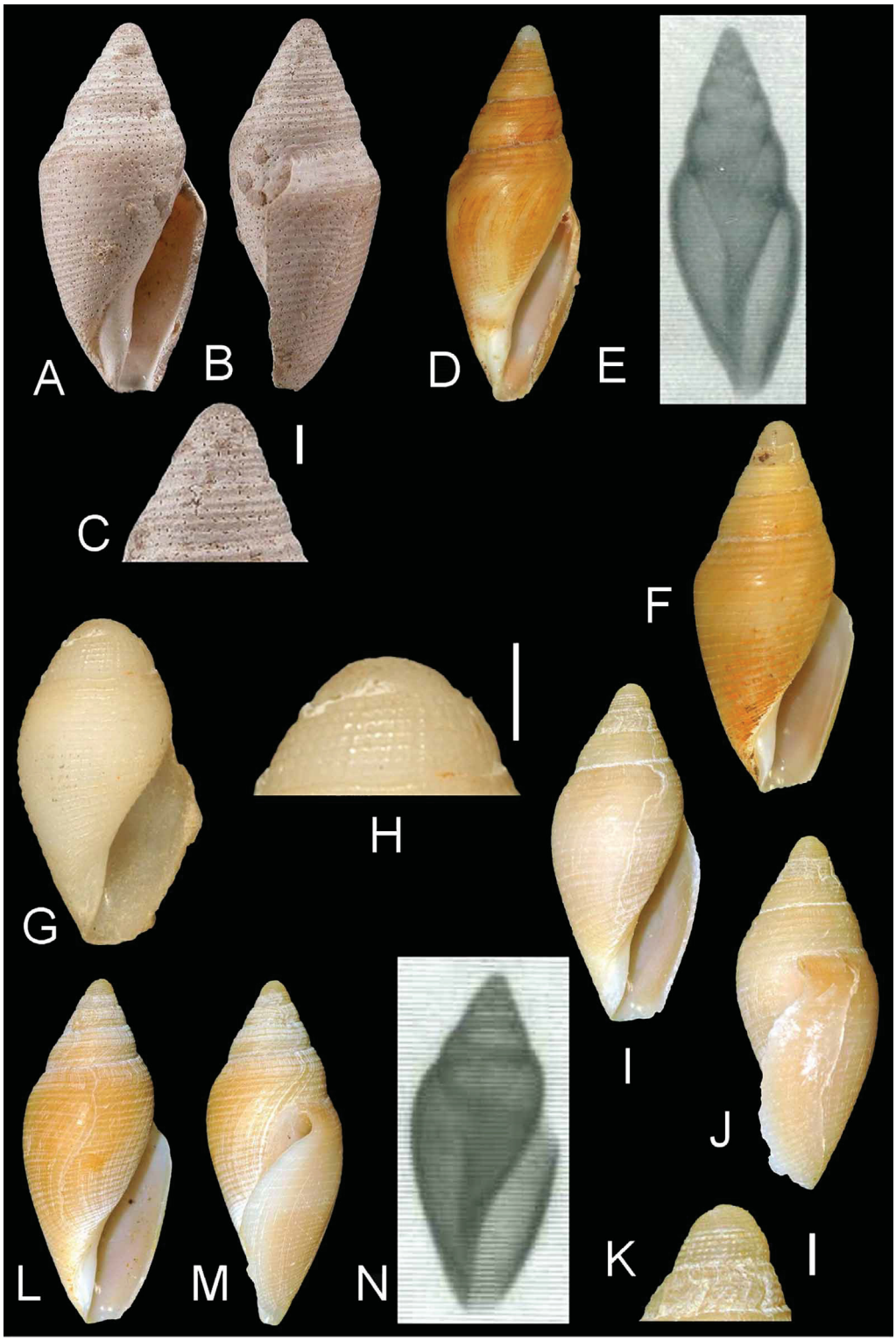

FIGURE 1. A–C. Holotype of *Benthofascis biconica* (AMS C.016448, 35–37 m deep, Shoalhaven Bight, New South Wales, Australia), height 18 mm, width 8 mm, ventral (**A**) and side (**B**) views with enlargement of spire (**C**). **D–E**. *Benthofascis biconica* (AMS C.468235, 5.7 km E of Mistral Point, Sydney, New South Wales, 33º56.470'S, 151º19.630'E, 71–77 m deep), heigth 29.8 mm, width 10.7 mm, ventral view (**D**) and x-ray (**E**). **F**. *Benthofascis biconica* (AMS C.468235, same locality data as above), height 17.9 mm, width 7.7 mm. **G–H**. Holotype of *Benthofascis sarcinula* (AMS C.19871, 203 m deep, 20 km miles E of Cape Byron, New South Wales, Australia), height 7 mm, width 4 mm, ventral view (**G**) and an enlargement of the spire (**H**). **I–K**. *Benthofascis sarcinula* (USNM 902892, SSE of Lakes Entrance, Gippsland Lakes, Victoria, Australia), height 16.6 mm, width 7.4 mm, ventral (**I**) and lateral views (**J**) with an enlargement of the spire (**K**). **L–N**. *Benthofascis sarcinula* (USNM 902893, Victoria, Australia), height 24.6 mm, width 10.7 mm, ventral (**L**) and lateral (**M**) views and an x-ray (**N**). Scale bars represent 1 mm.

Description. Shell solid, biconical, slightly angled at the shoulder, of more than six whorls. Color apparently flesh-tint. Sculpture: below the shoulder the shell is furrowed by numerous fine spiral grooves, crossed by arcuate growth lines, above the furrows are broader and fewer. Aperture narrow, sinus sutural and deep, outer lip appears to have curved far forward, columella angled in center, spreading broadly and with a small anterior plication. Length, 18 mm; breadth, 8 mm (quoted from Hedley 1903, p. 385–386). Inner shell walls are resorbed (Fig. 1E). The operculum is leaf-shaped with a terminal nucleus. It is fairly large and covers most of the apertural opening. The operculum of a specimen (AMS C.468234) with a shell length of 15.2 mm measured 3.25 mm in length. We examined a total of 28 specimens that could be accurately measured. Shell length for these averaged 26.4 mm (range = 10.1–41.8 mm). Shell width averaged 10.7 mm (range = 4.6–17.6 mm). The radula has a barb and blade at its anterior end (Figs. 4A–D). The barb is sharply tipped and this distal tip is curved away from the shaft of the tooth. The barb is about one-third as long as the blade. The distal end of the blade slopes towards the shaft of the tooth and is not much elevated above the shaft of the tooth. There is no anterior fold but there is a C-fold. This fold demonstrates that the tooth is enrolled a minimum of 360 degrees. There are no serrations and no terminating cusp. There is a fold on the shaft of the tooth that begins posterior to the distal end of the blade. This fold extends to the waist of the tooth (Figs. 4A & C). The tooth has a slight but distinct waist.

Discussion. Hedley (1903) aptly described the holotype of this species (Figs. 1A–C). Laseron (1954) reproduced Hedley's figure and correctly identified the species. However, some subsequent authors have misidentified specimens of *Benthofascis pseudobiconica* as *B. biconica* (e.g. Powell 1966; Wilson 1994; Tucker & Tenorio 2009). These two species are similar to each other but differ in shell shape. The shoulders of *B. biconica* are distinctly angular (Figs. 1A, D, & F), whereas those of *B. pseudobiconica* are not (Figs. 2E, G, & H). The more angular shoulders give *B. biconica* a stouter appearance compared to the long-bodied *B. pseudobiconica*.

Two other species have subangular shoulders, namely *B. angularis* (Figs. 2A & C) and *B. lozoueti* (Figs. 3I, K, & L). The latter species has a nearly smooth protoconch with more than 2 whorls (Fig. 3J), a feature unique among the *Benthofascis* species. Besides that *B. lozoueti* is unique among *Benthofascis* in that the inner shell walls are not remodeled (Fig. 3H). We were able to confirm via x-ray that all other species of *Benthofascis* remodel the inner shell walls. *B. angularis* does not have the punctate sutural ramps similar to those that *B. biconica* has.

The body whorl ornamentation of *B. conorbioides* differs from that of *B. biconica*. The former species (Figs. 3A, B, & D) and the two fossil species (Figs. 3E & F) have spiral grooves that are widely spaced and that cover the entire body whorl rather than the more closely spaced grooves of *B. biconica* and *B. pseudobiconica*. The body whorls of *B. lozoueti* (Figs. 3I, K, & L) and B. *angularis* (Figs. 2A & C) are almost smooth.

We illustrate the radulae of two of these species with micrographs and with drawings that show the internal structure of the teeth for the first time. Previous drawings (e.g., Powell, 1966) were misleading as they suggested that the teeth were simple hollow tubes with no internal structure (see Tucker & Tenorio, 2009). Electron micrographs available for *B. lozoueti* (Sysoev & Bouchet, 2001) also do not show internal structures. The radulae of *B. biconica* and *B. pseudobiconica* that we were able to examine had unexpected structures. There is a definite C-fold and a slight waist both features that were not obvious in previously published drawings of radulae from *Benthofascis*. This is important because it demonstrates that the tooth is enrolled more than 360 degrees. Moreover a fold is obvious along the shaft of the tooth in all three species. This fold may be homologous to the shaft fold that characterizes the Conilithidae (Tucker & Tenorio, 2009). However, this fold is not a shaft fold because it appears that in *Benthofascis* this fold is an internal one associated with the enrollment of the tooth. The shaft fold of the Conilithidae is an external structure.

Benthofascis sarcinula (Hedley, 1905)

Figures 1, G–N

Type material. Holotype is AMS C.19871, shell length 7 mm, shell width 4 mm.

Type locality. 111 fm, 12.5 miles E of Cape Byron, New South Wales, Australia

Other specimens. AMS C.372578 1 specimen from 73–91 m, off Bittangabee Bay, New South Wales, 37º13'S, 150º2'E; AMS C.372572 1 specimen from 26 m, N. Collaroy, off Long Reef, Sydney, New South Wales, 33º45'S, 151º19'E; USNM 902893, 2 specimens from Victoria, Australia; USNM 902892, 1 specimen from Lakes Entrance, Gippsland Lakes, Victoria, Australia.

Range. New South Wales and Victoria, Australia.

Description. Shell small, solid, ovate-fusiform. Color, pale yellow, with a rusty tinge at the suture. Whorls, three and a half, including a protoconch of one flat whorl. Sculpture, on the protoconch fine spiral grooves, continued on the adult as broad, shallow furrows, which are broadest at the suture becoming smaller and closer anteriorly. On the last whorl are twenty-two spiral ribs, on the penultimate six; the latter are latticed by fine radial riblets. The whole shell is crossed by fine arcuate growth lines. Aperture narrow, sinus deep, lip thin, straight, produced medially, edges crenulated by the sculpture. No callus on the inner lip. Columella broad and twisted; canal not produced. Length, 7 mm, breadth, 4 mm. (quoted from Hedley 1905, p. 53–54). The inner whorls are resorbed (Fig. 1N). The radula and operculum is not known.

Discussion. The species was described from a juvenile specimen only 7 mm long (Figs. 1G & H). Hedley was not certain about its generic identity having moved it from *Bathytoma* Harris & Burrows, 1891 to *Apaturris* Iredale, 1917 (Hedley 1918) and later to *Teleocheilus* Harris, 1897 (Hedley 1922). Cotton (1947) placed it in *Benthofascis*. Laseron (1954) left the species in *Benthofascis*. We examined three larger specimens identifiable as *B. sarcinula* (shell length 16.6 mm to 24.7 mm) in the collections of USNM (Figs. 1I–N). The morphology of their protoconchs (Fig. 1K), the resorbed inner whorls (Fig. 1N) and the rounded biconic shell shape (Figs. 1L & M) demonstrate that the species is a *Benthofascis*.

The species is closest to *Benthofascis conorbioides* (Figs. 3A–D) in shell shape but most similar to *B. pseudobiconica* (Figs. 2E–K) in morphology of the early teleoconch whorls. Both *B. conorbioides* and *B. sarcinula* have distinctly convex sides. The sutural ramps of early teleoconch whorls of all three species have axials and spirals equal in size. However, *B. sarcinula* has more numerous spirals (6+) than do *B. conorbioides* and *B. pseudobiconica* (3–4 spirals) on the sutural ramps of the first few teleoconch whorls. We conclude that *B. sarcinula* is a valid species of *Benthofascis* not conspecific with any of the other species.

Benthofascis angularis **new species**

Figures 2, A–D

Type material. Holotype in MNHN 23067and paratype in P. Stahlschmidt collection both found among red and green algae, low limestone reef with some taller kelp, 12–15 m, Duke of Orleans Bay, Esperance, southwest Western Australia.

Type locality. 30 m, off Cape le Grande, Esperance, southwest Western Australia.

Range. Known only from Esperance, Western Australia.

Description. Shell is small but is solid and ovate-fusiform. The holotype is 27.5 mm long and 11.1 mm wide. The paratype is 25.3 mm long and 11.0 mm wide. Color pattern consists of yellow bands over white. Three colored bands are present on the teleoconch whorls with one at the shoulder, one near midbody and the other at the anterior end. The midbody and anterior end bands may fuse into a single band. Spire is mostly white but a pale yellow band is located on the last teleoconch whorl. The holotype has 5.5 whorls including the protoconch. Sculpture on the protoconch consists of fine spirals. There are 4 or 5 spirals on the early sutural ramps of the teleoconch. The spirals are more pronounced than the axials, which appear to be enhanced growth lines. The number of spirals is reduced on the sutural ramps of the outer teleoconch whorls to two. Here, only growth lines cross the interspaces between the spirals. The body whorl is ornamented by spiral grooves. On the posterior half of the shell these grooves are widely spaced but they are set closer together on the anterior half of the body whorl. They are not overly distinct and best seen under magnification. The sides of the body whorl are slightly convex anterior to the shoulder angle. The shoulder is distinct almost carinate. The aperture is narrow with a deep sinus, the lip is thin, straight and is produced medially. Inner shell walls are resorbed (Fig. 2D). The columella is nearly straight but does have a medial prominence. There is also a groove near its posterior end just where the columella meets the body whorl. This forms a denticle inside the aperture. The anal sinus is not symmetrical and is deepest at the suture. The protoconch is paucispiral, blunt and swollen looking. The operculum is leaf-shaped with a terminal nucleus (Fig. 2A). It is fairly large and covers much of the apertural opening. The operculum of the holotype is 5.92 mm long. The radula was not observed.

Discussion. This species can be distinguished from all other species of *Benthofascis* by the angular, almost carinate shoulder. In respect to the shell shape *Benthofacies angularis* is most similar to *B. lozoueti*. Both species are

easily separated by the smooth body of *B. angularis* and the difference in the protoconch which is covered with minute and numerous spirals in *B. lozoueti* and only 5 spirals in *B. angularis*. In addition both species differ in respect to the inner whorls: in *B. angularis* the inner whorls are resorbed, but *B. lozoueti* appears to lack internal shell remodelling. The sutural ramps of early teleoconch whorls have reduced development of axials resembling *B. pseudobiconica* (Fig.2J). However, the shoulder of that species is much less angular than that of *B. angularis*. The shoulder of *B. biconica* (Figs. 1A & B) is subangular but not as angular as that of *B. angularis*. The latter species also differs in ornamentation of the sutural ramps of early teleoconch whorls from *B. biconica*. The spirals and axials on the sutural ramps of *B. angularis* are not strongly developed. On the outer sutural ramps simple growth lines replace the axials. In *B. biconica*, the spirals are much larger than the axials but the axials between adjacent spirals are much larger than are the growth lines.

This species is also the only *Benthofascis* species collected from Western Australia. More importantly, the holotype was collected in only 12–15 m water depth. With only a few exceptions other species of *Benthofascis* occur in deeper water.

Etymology. The name refers to the angular shoulders that characterize the species.

Benthofascis pseudobiconica new species

Figures 2, E–K; 4, E & F

Type material. Holotype: MNHN 23069, 39.8mm x 12.8 mm, off Cape Moreton, Queensland, Australia. Paratypes: USNM 902891, 2 specimens from the Indian Ocean of South Australia; USNM 845059, 2 specimens from 80 fathoms, Stradbroke Island, Moreton Bay, Queensland, Australia; ANSP 424978, 4 specimens from 100 fathoms, off Cape Moreton, Queensland, Australia; ANSP 303729, 2 specimens from 80 fathoms, off Cape Moreton, Queensland, Australia; SMF 335128, 1 specimen from trawlers at 200 m, on sand and rubble, off Bundaberg, central coast of Queensland, Australia; SBMNH 424098, 1 specimen from shell dredge at 160 m, east of Mooloolaba, southern Queensland, Australia; Peter Stahlschmidt collection, 2 specimens from 100–120 m, off Capricorn Channel, Queensland, Australia; AMS C.110615, 2 specimens from 132–155 m, off Mooloolaba, Queensland, 26º40'S, 153º36'E; AMS C.392807, 2 specimens from 128–183 m, E of Caloundra, Queensland, 26º48'S, 153º, 35'E; AMS C.373105, 2 specimens from 71–77 m, 5.7 km E of Mistral Point, Sydney, New South Wales, 33º56.470'S, 151º19.630'E (wet).

Other specimens. AMS C.383084, 4 specimens from 216–227 m, off Swain Reefs, off Hixson Cay, Queensland, 22º33'S, 153º26'E; AMS C.468236, 1 specimen from 115–176 m deep, East of Moreton Bay, Queensland, 26º55'S, 153º33'E, dredged 1969; AMS C.111073, 2 specimens from 201 m, off S end of Fraser Island, Queensland, 27º57'S, 153º51.050'E; AMS C.388791, 2 specimens from 66m, 5.6 km E of North Head, Sydney, New South Wales, 33º49.600S, 151º21.700E, dredged 18 January 1973, station SBS 21; AMS C.397151, 2 specimens from 128–137 m, off Tweed Heads, New South Wales, 28º19'S, 153º50'E; AMS 392811, 5 specimens from 187 m, SE of Swain Reefs, Queensland, 22º20.2'S, 153º17.130'E; AMS C.388787 3 specimens from 66 m, 5.6 km E of North Head, Sydney, New South Wales, 33º49.5'S, 151º21.8'E, dredged 26 April 1973, station SBS 1; AMS C.373099, 3 specimens from 71–77 m, 5.7 km E of Mistral Point, Sydney, New South Wales, 33º56.470'S, 151º19.630'E (wet); AMS C.388789, 11 specimens from 71–77 m, 5.7 km E of Mistral Point, Sydney, New South Wales, 33º56.470'S, 151º19.630'E, dredged, 20 July 1972, Station: SBS 2; AMS C.388794, 10 specimens from 115–176 m deep, East of Moreton Bay, Queensland, 26º55'S, 153º33'E, dredged 1969; AMS C.110614, 5 specimens from 101–128 m, East of Caloundra, Queensland, 26º45'–26º50'S, 153º34'–153º36'E; AMS C.101223, 6 specimens from 128–183 m, 12–15 miles NNE of Cape Moreton, Queensland, 27º00'S, 153º34'–153º36'E; AMS C.388788, 3 specimens from 115–175 m, off Moreton Bay, Queensland, 27º10'S, 153º, 40'E; AMS C.372589, 3 specimens from 9 m, Twofold Bay, New South Wales, 37º5'S, 149º55'E; AMS C.468231, 1 specimen from 201 m, off S end of Fraser Island, Queensland, 27º57'S, 153º51.050'E; AMS C.388782 4 specimens from 73 m, off Tweed Heads, New South Wales, 28º17'S, 153º44'E; AMS C.468234 1 specimen from 71–77 m, 5.7 km E of Mistral Point, Sydney, New South Wales, 33º56.470'S, 151º19.630'E (wet); ANSP 310029, 4 specimens from 100 fathoms, off Cape Moreton, Queensland, Australia; SBMNH 424099, 1 specimen from shell dredge at 160 m, east of Mooloolaba, southern Queensland, Australia.

Type locality. Cape Moreton, Queensland, Australia

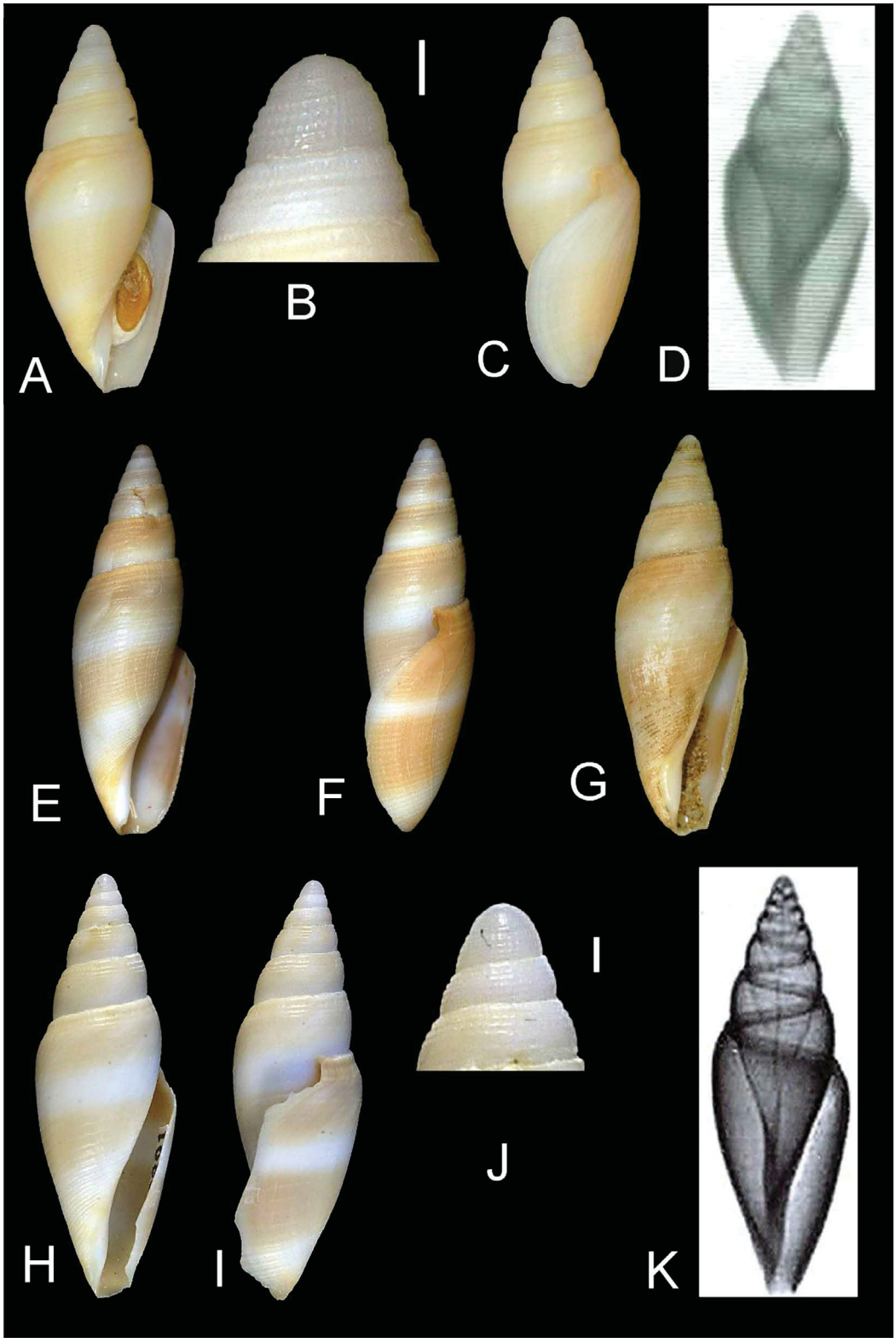

FIGURE 2. A–D. Holotype of *Benthofascis angularis* new species (MNHN 23067, 30 m deep, off Cape le Grande, Esperance, southwest Western Australia), height 27 mm, width 11.1 mm, ventral (**A**) and lateral (**B**) views with enlargement of spire (**C**) and an x-ray (**D**). **E, F**. Holotype of *Benthofascis pseudobiconica* new species (MNHN 23069, off Cape Moreton, Queensland, Australia), height 39.8mm, width 12.8 mm, ventral (**E**) and lateral (**F**) views. **G.** Paratype of *Benthofascis pseudobiconica* new species (ANSP 424978, 183 m deep, off Cape Moreton, S. Queensland, Australia), height 35.3 mm, width 11.8 mm, ventral view. **H–K.** Paratype of *Benthofascis pseudobiconica* new species (USNM 902891, South Australia, Australia) height 36.4 mm, width 12.4 mm, ventral (**H**) and lateral (**I**) views with an enlargement of the spire (**J**) and an x-ray (**K**). Scale bars represent 1 mm.

Range. Queensland and New South Wales, Australia.

Description. Shell moderate in size, up to 42.4 mm long, solid, ovate-fusiform. We examined a total of 42 specimens that could be accurately measured. These averaged 27.8 mm long (range = 12.8–42.4 mm). They averaged 9.9 mm wide (range = 5.7–14.9 mm). Color pattern is banded with tan to yellow bands separated by areas of white. Three colored bands are present on the teleoconch whorls with one at the shoulder, one near midbody and the other at the anterior end. Sutural ramp has a colored band at the suture and a white area anterior to the colored band. Larger specimens have 6.7 to 7 whorls including the protoconch. Sculpture on the protoconch consists of fine spiral grooves. There are more than 4 spirals on the early to middle teleoconch sutural ramps. The spirals and axials are of the same size and do not produce a punctate appearance. The number of spirals is reduced on the outer teleoconch sutural ramps to two or three that are crossed by growth lines. The teleoconch is ornamented by closely set spirals separated by narrow interspaces. The sides of the body whorl are slightly convex but not flattened. The shoulders are indistinct. The aperture is narrow with a deep sinus, the lip is thin, straight and is produced medially. Inner shell walls are resorbed (Fig. 2K). The columella is nearly straight. There is a groove near its posterior end just where the columella meets the body whorl. This forms a denticle inside the aperture. The anal sinus is not symmetrical and is deepest at the suture. The protoconch is paucispiral, blunt and swollen looking. The operculum is leaf-shaped with a terminal nucleus. It is fairly large and covers most of the apertural opening. The operculum of a specimen (AMS C.373099) with a shell length of 17.3 mm measured 3.65 mm in length. Previous drawings of the radula suggested that it is simple with a barb and blade (see Powell 1966; Tucker & Tenorio 2009, as *B. biconica*). However, the tooth has more internal structure than previously known (Figs. 4E & F). The barb is blunt tipped and is about one-third as long as the blade. The distal end of the blade is elevated above the shaft of the tooth and slopes to meet the tooth shaft. There is no anterior fold but there is a C-fold. This fold demonstrates that the tooth is enrolled a minimum of 360 degrees. There are no serrations and no terminating cusp. There is a fold on the shaft of the tooth that begins posterior to the distal end of the blade. This fold extends to the waist of the tooth (Fig. 4E). The tooth has a slight but distinct waist.

Discussion. This species has been confused with *Benthofascis biconica* (Figs. 1A–C), which it does resemble. The comparison to *B. biconica* is given under that species but in summary the two can be separated by body whorl shape and ornamentation of the first two whorls. In *B. biconica* the shoulders are more angular than in *B. pseudobiconica*. The early whorls of *B. biconica* have spirals and axials strongly developed, whereas in *B. pseudobiconica* the axials are hardly developed at all initially. *B. angularis* (Figs. 2A & C) has even more angular shoulders than does *B. pseudobiconica*.

Etymology. The name underscores the similarities that the new species shares with *Benthofascis biconica*.

Benthofascis conorbioides new species

Figures 3, A–D

Type material. Holotype in MNHN 23068 (38.6 mm long, 15.1 mm wide); Paratypes: SBMNH 424097, 1 specimen from the type locality; Peter Stahlschmidt collection, 1 specimen trawled by prawn trawlers, on sand and rubble, off Bundaberg, central coast of Queensland, Australia.

Type locality. 80–120 m, off Mooloolaba, southern Queensland, Australia.

Range. Known only from Queensland, Australia.

Description. Shell is moderate in size. The three specimens of the type series averaged 43.3 mm long (range = 38.6–49.6 mm). The mean shell width was 16.3 mm (range = 15.1–17.0 mm). It is solid and ovate-fusiform. Color pattern consists of flesh colored bands over white. Two narrow colored bands are present on the teleoconch with one at the shoulder and one near midbody. The anterior end is shaded slightly. Sutural ramp of the spire is also banded with this flesh color. The larger specimen has 6.5 whorls including the protoconch. Sculpture on the protoconch consists of fine spiral grooves. There are 4 or 5 spirals on the sutural ramps of the early teleoconch whorls. The axials are not developed but growth lines cross the spaces between adjacent spirals. On the sutural ramps of outer teleoconch whorls the number of spirals is reduced to 2 to 4. Growth lines cross the interspaces between adjacent spirals. The body is ornamented by deep, pronounced spiral grooves separated by interspaces of varying width. On the posterior half of the shell these interspaces are slightly wider than they are on the anterior half of the body whorl. The sides of the body whorl are convex and the shoulder angle is exceedingly indistinct. The aperture

is narrow with a deep sinus, the lip is thin, straight and is produced medially. Inner shell walls are resorbed (Fig. 3C). The columella is nearly straight. There is a groove near its posterior end just where the columella meets the body whorl. There is a denticle inside this groove. The anal sinus is not symmetrical and is deepest at the suture. The protoconch is paucispiral, blunt and swollen looking. The operculum and radula were not observed.

Discussion. This species with its deep widely spiral grooves and interspaces of variable width looks nothing like the other species of *Benthofascis* included here. It more closely resembles two fossil species from the Miocene (Fig. 3E) and Oligocene (Fig. 3F) of Australia. These were both placed in *Conorbis* by various authors (Tucker 2004 for a review; Tucker & Tenorio 2009). The species are *Benthofascis atractoides* (Tate 1890) new combination (Fig. 3E) and *B. otwayensis* (Long 1981) new combination (Fig. 3F). The latter species from the Oligocene of Victoria was originally described as a subspecies of the former, a Miocene species from South Australia. Of these two species, the Miocene *B. atractoides* is closest to *B. conorbioides*. The Oligocene species, *B. otwayensis* is wider bodied (holotype shell width/shell length = 0.47) than is *B. atractoides* (holotype shell width/shell length = 0.40) or *B. conorbioides* (type series: shell width/shell length mean = 0.39 (range = 0.34–0.40). Recognition of these Australian fossils as members of *Benthofascis* extends the geologic history of the genus to the Oligocene.

Although superficially similar, *Benthofascis conorbioides* and *B. atractoides* differ in the length of the aperture compared to the length of the shell. *B. conorbioides* has a much longer aperture than does *B. atractoides*. The aperture of *B. conorbioides* ranges from 57% to 62% (mean = 59%, n = 3) of the length of the shell. In contrast the aperture of the holotype of *B. atractoides* is 55% of the length of the shell. This can be confirmed by finding the point on the body whorl where the suture of the last whorl with the body whorl is located. This point is located well anterior to the shoulder in *B. atractoides* (Fig. 3E). In *B. conorbioides* the point where the suture of the last whorl meets the body whorl is almost at the shoulder slope (Fig. 3A). This may seem a small difference but it results in a lowered degree of scalariformity, which is also an important trait in distinguishing Eocene and Recent cone shells (Kohn 1990).

This species resembles certain species of *Bathytoma* such as *Bathytoma atractoides* (Watson 1881). Both have rounded convex sides and bodies ornamented by ridges and sulci. Both also have similar color patterns. However, *Benthofascis conorbioides* cannot be a *Bathytoma* because *Benthofascis conorbioides* has the inner whorls resorbed (Fig. 3C). In contrast *Bathytoma atractoides* does not (Tucker & Tenorio 2009, Fig. 17F). Protoconchs also differ markedly. The protoconch of *Bathytoma* species is smooth and has a narrow point (Powell 1966). In contrast the protoconchs of *B. conorbioides* and other *Benthofascis* species are blunt and ornamented with spirals. The anal sinus of *Bathytoma* species is also more u-shaped because its deepest point is near the center of the subsutural ramp. The anal sinus of *B. conorbioides* and other *Benthofascis* species is deepest near the shoulder.

Etymology. The name is suggested by the superficial similarity between *Benthofascis conorbioides* and species of the extinct genus *Conorbis*.

Benthofascis lozoueti Sysoev & Bouchet, 2001

Figures 3, G–L; 4, G

Type material. Holotype and 2 paratypes in MNHN, 1 paratype each in NMNZ, AMS, NMSA.

Type locality. 530 m, Norfolk Ridge, 22º58'S, 167º20'E

Range. Known only from the type locality.

Description. Shell biconic, rather thick, with moderately high spire, comprising 30% of shell height. Protoconch very large, diameter *ca.* 2500 μm, dome-shaped, consisting of about 2 rapidly expanding whorls, transition to teleoconch indistinct; initial whorl strongly flattened; sculpture of very fine spiral and axial lines. Teleoconch whorls 4, weakly convex, subsutural ramp unclearly defined, especially on early whorls. Suture weakly channeled. No axial sculpture. Spiral cords weak, low, with wide interspaces, much stronger on subsutural ramp and canal, very weak on whorl periphery. Base almost flat. Canal short, broad, strongly turned abaxially, slightly notched. Aperture rather narrow, pyriform. Inner lip evenly curved, with concave columellar part, covered by narrow but thick callus. Anal sinus is broad and shallow, occupying entire subsutural ramp, outer lip greatly projecting below sinus, most strongly projecting below its middle. Color white, periostracum very thin, yellowish. Dimensions: shell length 21.5 mm, last whorl height 15.0 mm, aperture length 11.5 mm, shell width 9.1 mm. The radular tooth is relatively large with a long, narrow, straight blade and a small rounded basal part (Fig. 4G). The operculum is narrow with a large terminal nucleus. (description is adapted from Sysoev & Bouchet 2001, p. 292).

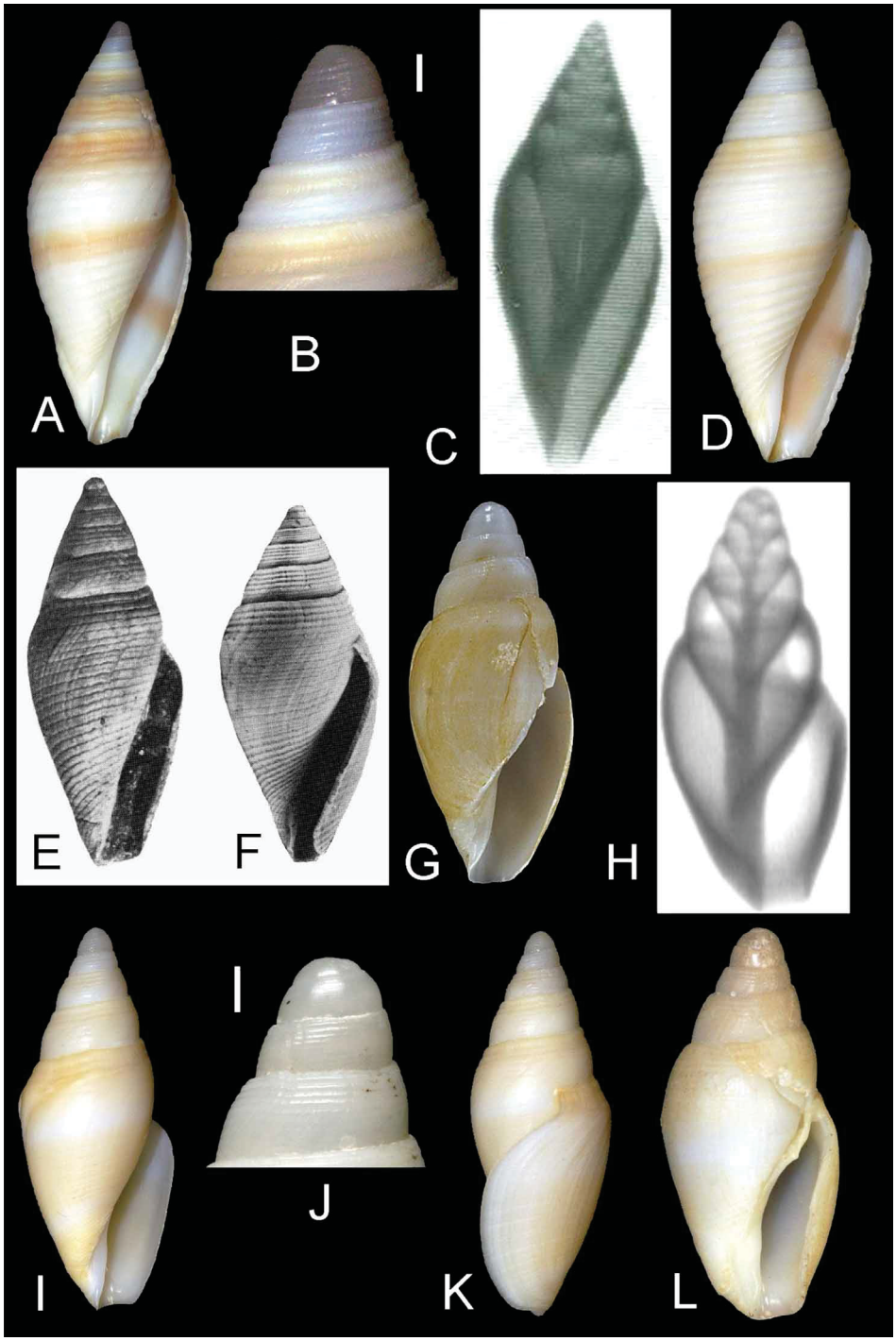

FIGURE 3. A–C. Holotype of *Benthofascis conorbioides* new species (MNHN 23068, trawled 80–120 m, off Mooloolaba, S. Queensland, Australia), height 38.7 mm, width 15.4 mm, ventral view (**A**), with an enlargement of the spire (**B**) and an x-ray (**C**). **D**. Paratype of *Benthofascis conorbioides* new species (SBMNH 424097, trawled on sand and rubble, 80–120 m, off Mooloolaba, S. Queensland, Australia) height 41.8 mm, width 17.0 mm, ventral view. **E**. Holotype of *Benthofascis atractoides* (SAMA T750A, Kent Town Bore, Clayey greensands, Janjukian?, L. Miocene), height 16.5 mm, width 6.5 mm (reproduced from Long, 1981, Pl. 6, Fig. 14, with permission), ventral view. **F**. Holotype of *Benthofascis otwayensis* (NMVM P42959, Point Flinders, Cape Otway, Victoria, Australia. Glen Aire Clay, U. Aldingan, L. Oligocene), height 19.75 mm, width 8.75 mm (reproduced from Long, 1981, Pl. 6, Fig. 15, with permission), ventral view. **G**. Paratype of *Benthofascis lozoueti* (NMSA L5679/T1867), South New Caledonia, N/O "Alis" campaign, Stn. DW 721, 22º54'S, 167º17'E, height 16.5 mm, width 7.2 mm, ventral view. **H.** *Benthofascis lozoueti* (MNHN IM200742331, 496 m deep, Norfolk Ridge, 22º50'S, 167º16'E), length 16.4 mm, width 7.0 mm, x-ray. **I–K**. Holotype of *Benthofascis lozoueti* (MNHN 3053, 530 m deep, Norfolk Ridge, 22º58'S, 167º20'E), height 21.5 mm, width 15 mm, ventral (**I**) and lateral (**J**) views with an enlargement of the spire (**K**). **L**. Paratype of *Benthofascis lozoueti* (AMS C.415308), 525–574 m deep, New Caledonia, 22º54'S, 167º17'E, height 17.5 mm, width 8.0 mm, ventral view. Scale bars represent 1 mm.

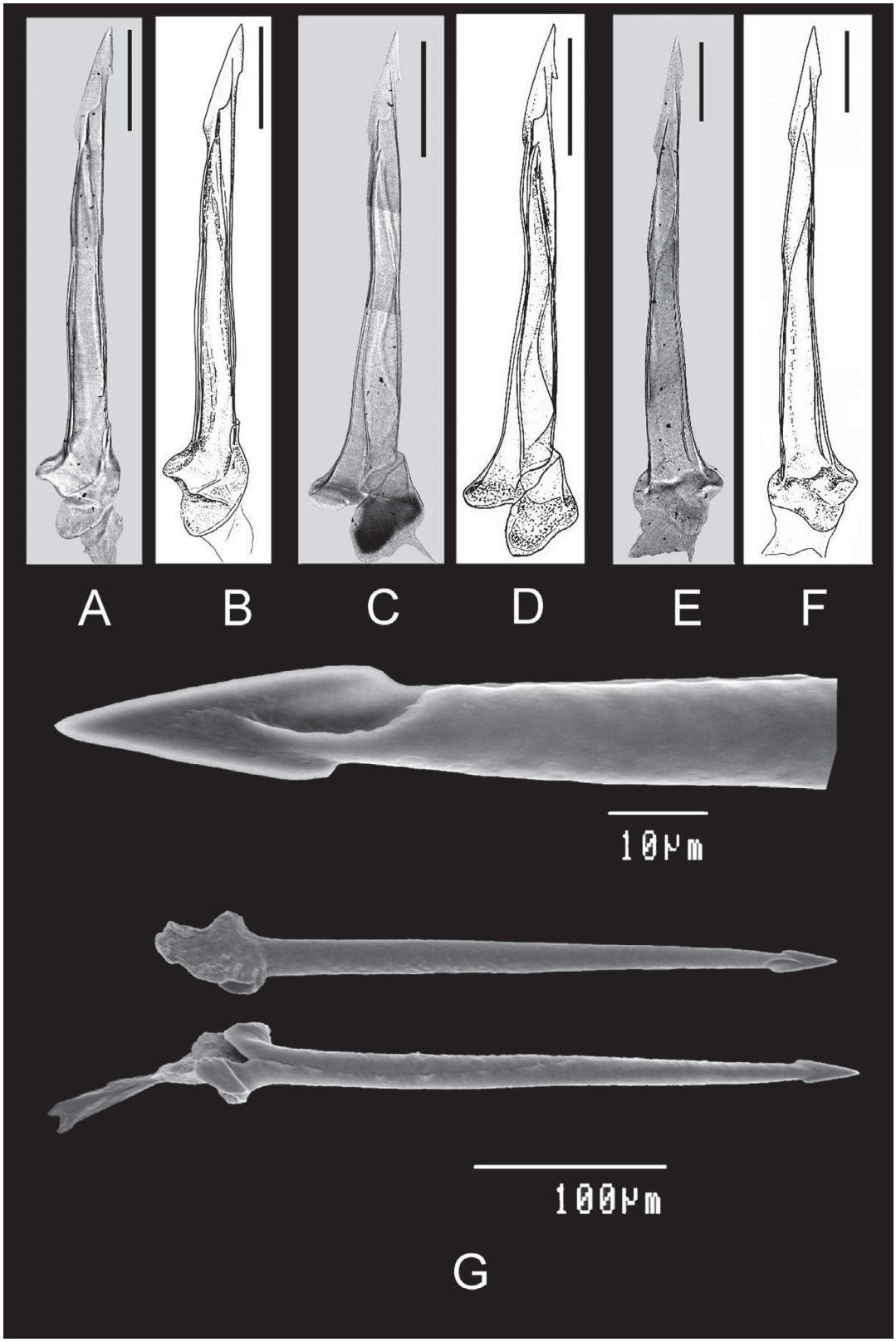

FIGURE 4. A, **B**. Radular teeth extracted from *Benthofascis biconica* (AMS C.468232, shell length of 15.5 mm), photomicrograph (**A**) and drawing (**B**) showing internal structures. **C**, **D**. Radular teeth extracted from *Benthofascis biconica* (AMS C.468234, shell length of 15.2 mm), photomicrograph (**C**) and drawing (**D**) showing internal structures. **E**, **F**. Radular teeth extracted from *Benthofascis pseudobiconica* (AMS C.373099, shell length of 17.3 mm), photomicrograph (**E**) and drawing (**F**) showing internal structures. Scale bar represents 0.1 mm for **A**–**F**. **G**. **G**. Electron micrographic study of the radular tooth of *Benthofascis lozoueti* Sysoev & Bouchet, 2001, (MNHN IM200742331, 496 m deep, Norfolk Ridge, 22º50'S, 167º16'E, height 16.4 mm, width 7.0 mm, teeth from the same specimen shown in Fig. 3H). Scale bar dimensions are explained in the figure.

Discussion. This species differs from all other *Benthofascis* in having the sculpture of the protoconch reduced to numerous exceedingly thin and minute spirals and by not having the inner shell walls greatly resorbed (Fig. 3H). Axials are also minute. The appearance is that of a smooth protoconch. Other *Benthofascis* species have much better developed spirals on the protoconch. The species is only provisionally considered a *Benthofascis* in light of the above differences.

Small specimens of *Benthofascis lozoueti* resemble the holotype of *B. sarcinula* in shell shape. Both have the whorls rounded and convex. However, the spirals and axials of the protoconch of *B. sarcinula* are more obvious than those of *B. lozoueti*. Larger specimens of *B. lozoueti* tend to be more angular and have an obvious shoulder. In this respect they resemble *B. angularis*. However, the latter species has a distinctly ornamented protoconch.

Acknowledgements

We thank Des Beechy, Alison Miller and Mandy Reid (AMS) for images of the holotypes of *Benthofascis biconica* and *B. sarcinula* and for permission to use them; Richard Kilburn and Igor Muratov (NM) provided images of one of the paratypes of *B. lozoueti;* Philippe Bouchet provided images of the holotype of *B. lozoueti*; Alison Miller loaned specimens from AMS; Paul Callomon and Gary Rosenberg loaned specimens from the ANSP collections, Jerry Harasewych loaned specimens from USNM. Joe Twigo made x-rays for us. Images of *B. atractoides* and *B. otwayensis* from the Memoirs of the National Museum of Victoria were reproduced with permission of the journal and we thank Richard Marchant, Museum Victoria for that. Nicolas Puillandre provided the x-ray image of *Benthofascis lozoueti*, which will be part of an upcoming paper on this species. Yuri Kantor kindly provided the electron microscopic study of the radular tooth of *B. lozoueti*.

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